

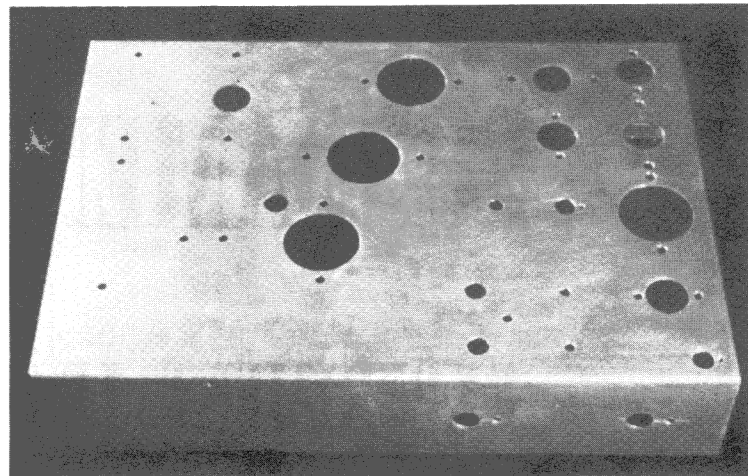
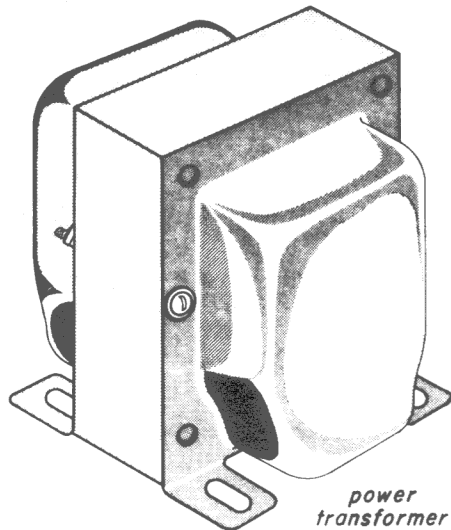
ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 13

GENERATOR AND TRANSFORMER EXPERIMENTS



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.



terminal strips

All the parts in Kit 7 are listed below. Check the parts you receive against this list. Make sure you have the correct quantity of every item. If a part is either missing or defective upon arrival, request a replacement from Department R, Home Study School, RCA Institutes, Inc., 350 West 4th Street, New York 14, N.Y. *Your request must include your name and student number, the complete name and description of the part copied from the Item column below, the Quantity missing or defective, and the reason you are asking for a new part.*

KIT 7

BILL OF MATERIALS

Quantity	Item	Quantity	Item
1	Power transformer	1	Resistor, 390-ohms, 1 watt
1	Radio receiver chassis	1	Resistor, 10 k-ohms 5-watts
4	1.5-volt dry cells	5'	^{FLAT - No. 63-2411} #20 solid hook-up wire
		5'	solder, rosin core

The parts listed below are contained in an envelope.

Quantity	Item	Quantity	Item	Quantity	Item
3	Octal tube socket	1	Terminal strip D	22	Nut, 6-32
3	7-pin miniature tube socket	1	Terminal strip E	8	Machine screw, round head, 4-36 x 1/4"
1	Phono jack	2	Rubber grommets 1/4" (ID)	8	Nut, 4-36
1	Terminal strip A	1	Rubber grommet 1/2" (ID)	8	Lock washer, #4
1	Terminal strip B	21	Machine screws, round head, 6-32 x 1/4"	4	Flat washer, #6
5	Terminal strip C	25	Lock washer, #6	3	Self-tapping screw, #6 x 1/4"

Experiment Lesson 13

PART 1

OBJECT

To use the a-c portion of your multimeter to make measurements of a-c voltages.

DISCUSSION

Now that you have completed the wiring of the a-c section of your multimeter, probably you are eager to make measurements with it. This part of this experiment lesson gives you directions for making certain measurements of a-c voltages. As you make these measurements, you will see what a useful tool the a-c section of your meter is. As you go on to later lessons, you will be able to make measurements that are even more interesting than the measurements that you are about to make. However, do not make any measurements other than the ones that you are told to make in this lesson until you learn more about a-c circuits. If you make a-c measurements without knowing exactly what you are doing, you may seriously damage your meter or injure yourself.

EQUIPMENT NEEDED

Two 10-megohm resistors (from Kit 1)

Line cord and plug

Soldering iron and solder

Multimeter

CHECK KIT

Unpack the parts in Kit 7 carefully, and check them against the parts listed and pictured on page 2. Return immediately any parts that you find broken or obviously de-

fective, together with the packing slip, to the address given on the packing slip.

After checking the parts, place all of the parts, except the line cord and plug, away in some safe place for use in the next Experiment Lesson.

EXPERIMENT 13-1

To measure an a-c voltage on different scales of your meter.

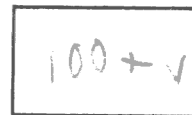
Procedure.

Step 1. Turn the FUNCTION switch on your meter to the AC position and the RANGE switch to the 1500 VAC position.

Step 2. Insert the black test lead into the black pin jack and the red test lead into the red pin jack.

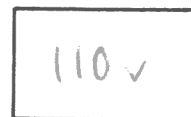
Step 3. Insert the test prods into an a-c outlet.

Step 4. Read the a-c scale of your meter and record the reading here:



Step 5. Turn the RANGE switch of your meter to the 300 VAC position.

Step 6. Read the a-c scale of your meter and record the reading here:



Step 7. Disconnect the test leads from the a-c outlet.

Discussion. Compare the reading that you recorded in Step 4 with the reading that you recorded in Step 6. The reading in Step 6 is probably somewhat closer to the

amount that you expected to read (the amount of a-c voltage that your electric power company tells you is supplied to your home).

The more accurate reading was obtained on the scale that measures, full scale, a voltage closer to the voltage you were measuring. Let's see why this should be so.

The movement of your meter is accurate to within $\pm 2\%$ on all of the scales. That means that a reading taken on the 1500 VAC scale is accurate to within $\pm 2\%$ of 1500 volts. In other words, any reading you get on the 1500 VAC scale may be 30 volts greater or 30 volts less than the reading you should get. If the voltage from your outlet is 120 volts, your reading might have been as high as 150 volts or as low as 90 volts. In other words, there might have been a difference as great as 60 volts between the reading you obtained on your meter and a reading obtained on another meter. When you consider that an error of 30 volts one way or the other equals one fourth of the voltage you are measuring, you can see that readings taken on a scale that is much higher than the voltage that you are measuring are not very useful.

On the other hand, the reading you got on the 300 VAC scale was more accurate. All the readings taken with the meter on the 300 VAC range are accurate to within $\pm 2\%$ of 300 volts. That means that the readings will be ± 6 volts at any point on the 300 VAC scale. When you measure 120 volts on the 300 VAC scale, your reading will be at most 126 volts and at least 114 volts.

Another way of thinking about this is to remember that readings taken in the upper end of a scale are more accurate than readings near the lower end of a scale.

When you are in doubt about the value of an a-c voltage that you are going to measure,

set your RANGE switch for the highest range. If the reading is not in the lower part of the scale, take the reading as final. If your reading is in the lower part of the scale and less than 300 volts, turn the RANGE switch to the next lower position. If, on the 300-volt range, the reading is still in the lower part of the scale and below 75 volts, turn the RANGE switch of your meter to the next lower (75-volt) range. Use the same procedure as before. If the reading is in the lower part of the scale and below 15 VAC, turn to the next lower range of your meter.

Information. The power wiring for homes supplied with electricity by local power and lighting companies fits one of two basic patterns throughout this country. The wiring is generally done with #14 BS wire, which safely carries 15 amperes. Pre-war homes usually have two 15-ampere circuits, while post-war homes may have four 15-ampere circuits. At one time, a 15-ampere line provided ample capacity for powering the kitchen and laundry equipment in most homes. Today, however, toasters, electric irons, washers, dryers, mixers, and other equipment call for more power than one line can safely carry. For this reason, home power wiring in modern homes is planned to handle such equipment.

The experiment that follows is best done in the kitchen, which is likely to be supplied by a line separate from the rest of the home. In the experiment, you will be asked to turn on lights and connect electrical appliances to a power outlet. When you do this, be careful not to overload the line. Look at the power rating in watts on the label of each piece of equipment before you add it to the circuit. Limit the total load to no more than 1,800 watts on a 120-volt line. Lower line voltages call for lower loads. For example, on a 110-volt line, a load of no more than 1,600 watts should be used.

EXPERIMENT 13-2

To measure the effects of changing the load on the a-c supply of your home.

Procedure.

Step 1. Turn out as many lights as possible and shut off all the electric appliances, such as toasters, vacuum cleaners, dishwashers, and washing machines.

Step 2. Turn the FUNCTION switch of your multimeter to AC and the RANGE switch to the 300 VAC position.

Step 3. Connect the black test lead to the black pin jack and the red test lead to the red pin jack. Insert the other ends of the test leads in an a-c outlet

Step 4. Take the reading on the a-c scale of your meter and record it here:

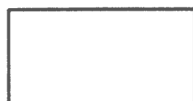


Step 5. Remove the test leads of your meter from the a-c outlet.

Step 6. Turn on lights and electrical appliances until the load is from 1,500 to 1,800 watts.

Step 7. Insert the test leads of your meter in an a-c outlet.

Step 8. Take the reading on the a-c scale of your meter and record it here:



Discussion. The reading you got in Step 4, when the lights and appliances were turned off, was higher than the reading you got in Step 8, when the lights and appliances were turned on. Let's see why this happened.

Figure 13-1 is a simplified block diagram of your power line system from the street main to the load (the lights and appliances in use). In many towns and cities, the

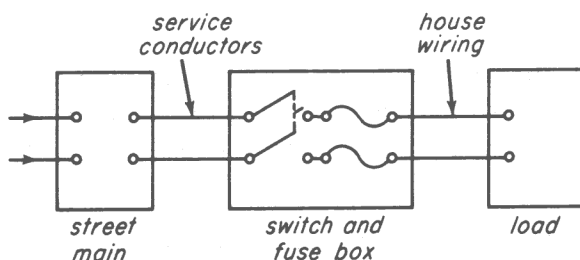


Fig. 13-1

electric-supply mains and service conductors may be enclosed in pipes or tubes, called *conduits*, that are buried in the ground. In other places, the service conductors may be overhead wires that are connected to mains strung on poles. Sometimes a connection is made to a *feeder* line that is, in turn, connected to a service main through a transformer. In fact, there are still other possible methods by which the service conductors from your home might be connected to the lines from the generating plant. No matter which system is used at your home, we are concerned only with your electric wiring from the point where connections are made to the street mains to the point where you connect a load.

The equivalent circuit of your electric wiring (very much simplified) is shown in Fig. 13-2. R_{line} represents the resistance of your wiring between the mains and the load. It shows the voltage available when no load is applied, and represents the reading that you took in Step 4. For all practical purposes, your meter is considered to draw no current. When no current flows, there is no voltage drop due to the resistance of the line (represented by R_{line}). As you remember from earlier lessons, current must flow before there is a voltage drop across a resistor. According to Ohm's Law, $E = IR$. If there is no current, the voltage (E) is equal to zero (I) times the resistance (R). Zero times R is, of course, zero.

If there is no voltage drop across R_{line} , then the entire voltage from the mains reaches your meter. Let's call this voltage the *emf*.

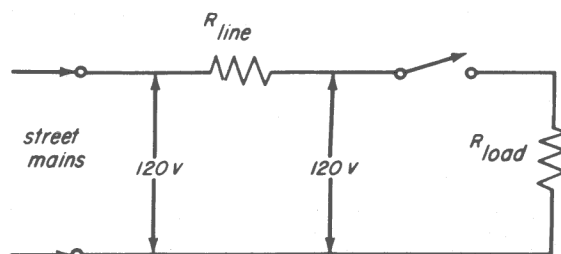


Fig. 13-2

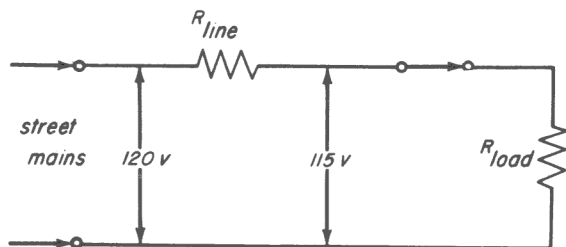


Fig. 13-3

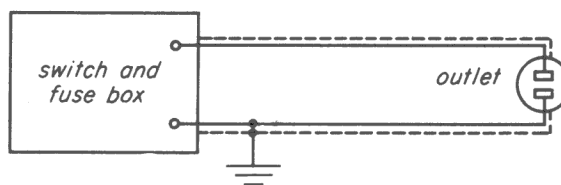
Figure 13-3 shows the same circuit with the switch closed. This is the condition when you have turned on lights and appliances. When these lights and appliances are on, they draw current. This current flows in the entire circuit. Therefore, there is a voltage drop across R_{line} .

If there is a voltage drop across R_{line} , there is less voltage reaching your meter (and the appliances). The greater the load on your power lines, the greater is the voltage drop due to line resistance, and the less is the voltage available to your light bulbs and appliances. So, the next time that you see your kitchen lights dim slightly as the toaster is plugged into the wall outlet or the refrigerator motor starts up, you'll know why. On the other hand, if your lights do not dim, you can be sure that your wiring system is designed to handle modern kitchen appliances.

EXPERIMENT 13-3

To use your meter to determine which side of an a-c outlet is grounded.

Discussion. In earlier lessons, you have read about an electric ground. In electric-power wiring, one of the two conductors connected to an electric socket or outlet is grounded. We call this the *grounded* or *low* side of the line. We speak of the ungrounded side as the *high* side of the line. In addition, the National Electrical Code requires that the metal pipes or other conduits that contain the power lines be grounded, too. In speaking of an electrical ground in radio and television circuits, we refer to a connection made to the chassis or a ground bus-bar wire. In speaking of an electrical ground in power



dashed lines show metal conduit

Fig. 13-4

wiring, we refer to a connection made to a wire or other metal conductor actually connected to the earth. Figure 13-4 shows the power-line circuit simplified. One side of the a-c line in your home is grounded in much the same manner. You can use the a-c section of your multimeter to find which is the high side and which the low, or grounded side.

Procedure.

Step 1. Set the FUNCTION switch of your multimeter to the AC position and the RANGE switch to the 300 VAC position.

Step 2. Put the black test lead in the black pin jack and the red test lead in the red pin jack.

Step 3. Put the red test lead into one of the holes in an a-c outlet.

Step 4. Touch the black test lead to a water pipe, a steam pipe, or some other good ground.

Step 5. Look at the scale of your meter. If the pointer is deflected so that you get a reading, the red test lead is connected to the high side of your outlet. Therefore, the other hole in your outlet is the grounded side. If you get no reading, the red test lead is attached to the grounded side of your meter.

Discussion. It is very helpful to any serviceman to be able to know which side of a line is grounded and to understand exactly what ground means.

Let us suppose that you are testing an a.c.-d.c. radio receiver that has one side of the power line grounded to its chassis. Then

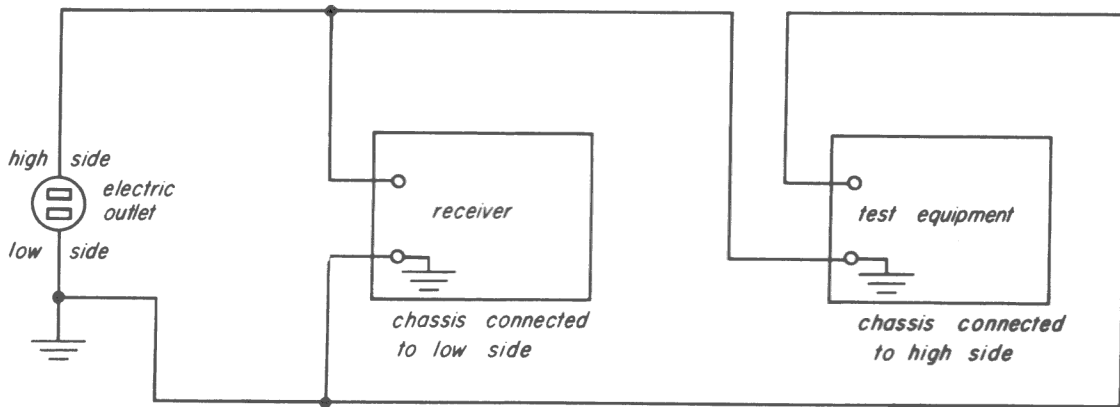


Fig. 13-5

suppose that you are using test equipment that also has one side of the power line grounded to its chassis. If you plug the receiver and the test equipment into the outlet so that the low side of the line is grounded to the receiver chassis and the high side is grounded to the test-equipment chassis, your connection will look like what is shown in Fig. 13-5. If you touch both chassis at the same time, the entire line voltage will pass through your body and give you a shock. If the two chassis touch each other or are connected together, either the power will be shorted and cause the fuse to blow or either (or both) the receiver or test equipment will be damaged. Trouble such as this may be avoided by knowing which is the grounded side of the line and connecting that side to each chassis.

vision, you will learn more about ground connections and more about the ways you may use your meter to test them.

EXPERIMENT 13-4

To learn how you may load an a-c circuit.

Preparation. In preparation for the next experiment, unsolder the 10 k-ohm and 100 k-ohm resistors from the resistor board that you made in Experiment Lesson 1. In their place, solder the two 10-megohm resistors that you received in Kit 6. Connect these two resistors in series and solder the a-c line cord across the free ends, as shown in Fig. 13-6.

Caution: Follow very carefully the instructions for each step in the following experiment. Unless you perform each step as instructed, you may damage your multimeter severely.

Step 1. Plug the line cord into a convenient a-c outlet.

Step 2. Set the FUNCTION switch of your multimeter to the AC position and the RANGE switch to the 300 VAC position.

Step 3. Measure the voltage across the two resistors in series (the line voltage) and record it here:

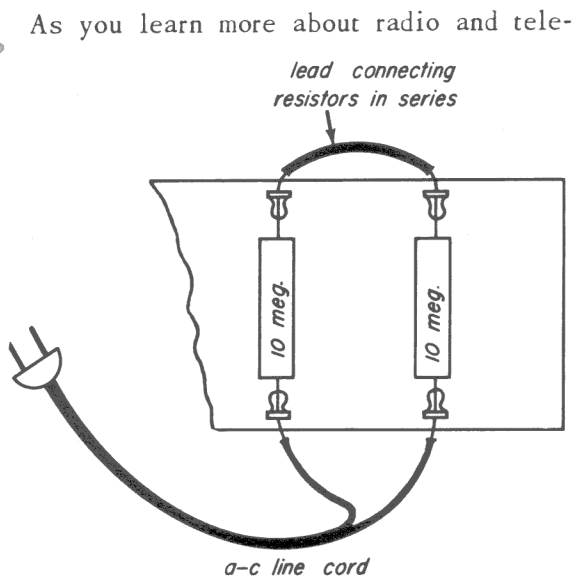


Fig. 13-6

108V

Step 4. Measure the voltage across one of the two 10-megohm resistors and record it here:

16V

Step 5. Measure the voltage across the other 10-megohm resistor and record it here:

16V

Step 6. Set the RANGE switch to the 75 VAC position.

Warning: In the following steps, do not measure the voltage across the line.

Step 7. Measure the voltage across one of the two 10-megohm resistors and record it here:

7V

Subtract this reading from the line reading made in Step 3 and record the answer here:

108
- 7

101

101V

Step 8. Measure the voltage across the other 10-megohm resistor and record it here:

7V

Step 9. Set the RANGE switch to the 15 VAC position.

Warning: In the following step, do not measure the voltage across the line.

Step 10. Measure the voltage across one of the two 10-megohm resistors and record it here:

1V

Subtract this reading from the line reading made in Step 3 and record the answer here:

107V

Step 11. Measure the voltage across the other 10-megohm resistor and record it here:

1V

Subtract this reading from the line reading made in Step 3 and record the answer here:

107V

Step 12. Remove the line cord from the electric outlet and then unsolder it from the resistor-board terminals.

Discussion. If you carefully followed the directions for Experiment 13-4, you obtained some interesting readings. What happened in this experiment is very important to your understanding of the conditions under which the a-c voltmeter section of your multimeter will give you satisfactory readings. If you understand what happens when you apply your a-c voltmeter to a circuit, even apparently inaccurate readings will prove useful to you. To help you understand, let us examine closely the three sets of readings you obtained and see if they can be explained satisfactorily.

First of all, we know that if two resistors of the same value are placed in series across a voltage source, the voltage drop across each will be the same. As there are two resistors, half the voltage will be across each. This means that, if you had a 120-volt line, half of this voltage should have appeared across each 10-megohm resistor, as shown in Fig. 13-7a. However, this voltage division occurs only *when the meter is not in the circuit*. Now let's see what happens when you apply the 300 VAC

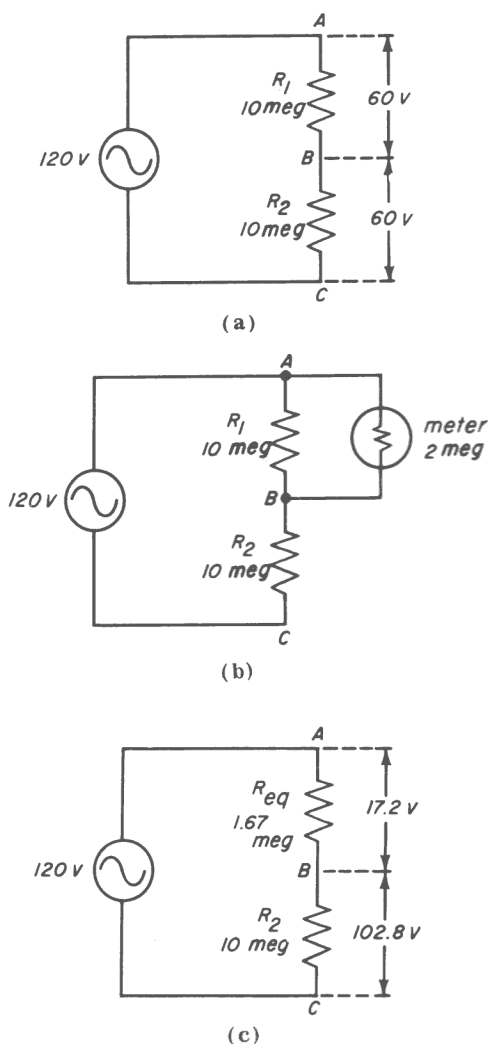


Fig. 13-7

range of your multimeter to the circuit. The resistance of your meter on this range is 2 megohms. Figure 13-7b shows the equivalent circuit when the meter's 2 megohms of resistance is connected across one of the 10-megohm resistors. Now, instead of a simple series circuit, we find a series-parallel combination. To find the effective resistance between points A and B, we use the familiar product-over-the-sum formula:

$$\begin{aligned}
 R_{eq} &= \frac{R_1 \times R_m}{R_1 + R_m} \\
 &= \frac{10 \times 10^6 \times 2 \times 10^6}{10 \times 10^6 + 2 \times 10^6} \\
 &= \frac{20 \times 10^{12}}{12 \times 10^6}
 \end{aligned}$$

$$= \frac{20 \times 10^6}{12}$$

$$= 1.67 \times 10^6 \text{ or } 1.67 \text{ megohms}$$

If we redraw the circuit to show the effective resistance in the circuit, as in Fig. 13-7c, we find that the resistance between A and B is actually only 1.67 megohms instead of the 10-megohms of resistance that was there without the meter.

The voltage drop across each section of this circuit will be in proportion to the resistance of each series section over the total series resistance. The total resistance in series is 10 megohms plus 1.67 megohms, or 11.67 megohms. Therefore, the voltage between points A and B may be found:

$$E_{A-B} = \frac{1.67}{11.67} \times 120$$

$$= 0.143 \times 120$$

$$= 17.2 \text{ volts}$$

The voltage across R_2 is, therefore, the difference between 120 volts and 17.2 volts, or 102.8 volts. However, when the meter was placed across R_2 , the reading was the same (or about the same) as for R_1 . So, each time it was connected, the meter loaded the circuit and changed the voltage division of the circuit.

When you took readings with the meter connected to the 75 VAC range, the voltage measured by the meter was even less than before. On the 75 VAC range, the meter resistance is only 0.5 megohm. So, when the meter was placed across one of the 10-megohm resistors, the resistance of that part of the circuit became (for all practical purposes) the same as that of the meter, or 0.5 megohms. The total series resistance became 0.5 plus 10 or 10.5 megohms. The voltage across the resistor being tested was then:

$$R = \frac{0.5}{10.5} \times 120$$

$$= 5.7 \text{ volts}$$

The rest of the 120 volts was across the other resistor. The meter loaded up the circuit so that the measured voltage was equal to less than 1/10 of the voltage that was there without the meter in the circuit.

When readings were taken on the 15 VAC range, they became still smaller. In this range, the meter resistance is only 0.1 megohm. When the meter was applied to one of the 10-megohm resistors, the resistance of that part of the circuit became practically 0.1 megohm. The voltage measured by the meter was equal to:

$$\frac{0.1}{10.1} \times 120 = 1.2 \text{ volts (approx)}$$

As you can see from this experiment, the a-c section of your multimeter loads a circuit when the resistance of the circuit is greater than the resistance of the meter range in use. There will be some loading when the meter resistance and the circuit resistance are about the same or when the circuit resistance is less than the meter resistance. However, when the meter resistance is ten or more times the resistance of the circuit under test, the loading effect is very small and may be disregarded.

When you know that the meter is loading a circuit, often you can tell whether or not the reading that you get is proper for the amount of loading that the meter offers. So, it is important that you know the resistance of the meter range and of the circuit being measured in order that you can judge the usefulness of the readings you obtain.

PART TWO

OBJECT

1. To identify the windings of a power transformer.

transformer

2. To study autotransformer action.

PREPARATION

Review the RETMA Color Code for power transformers in Theory Lesson 3.

EQUIPMENT NEEDED

1. Power transformer
2. A-C line cord
3. Multimeter

EXPERIMENT 13-5

To identify the power-transformer windings using the RETMA Color Code and ohmmeter checks.

Procedure.

Step 1. In an earlier lesson, you learned that the leads of the primary winding of the power transformer were *black*. Notice that this agrees with the RETMA Color Code for transformers. The transformer that we are using has five other leads in addition to the two black ones. Two leads are red, two are green, and one is red and yellow. Without referring to the RETMA Color Code, write the correct colors in the following blank spaces:

- a. The high-voltage leads of the secondary are:

Red

- b. The low-voltage leads of the secondary are:

Green

c. The center tap of the secondary is:

Red
+ yellow

d. The leads of the primary are:

Black

Step 2. To find out whether your answers are correct, you can test the transformer leads with your multimeter. Turn the FUNCTION switch of your multimeter to OHMS. Then turn the RANGE switch to the R x 100 position. Plug the test prods into the multimeter, and zero the meter, using the ZERO OHMS knob on the right side of the meter panel.

Step 3. Measure the resistance between the two black leads. Record this value here:

8 Ω

Step 4. Measure the resistance between the two red leads, and between one of the red leads and the red-yellow lead. Record these values here:

500 Ω 220 Ω

Step 5. Measure the resistance between the two green leads. If you find that the reading is very low on the R x 100 range, change to the R x 1 range, re-zero the meter, and take a new reading. Record it here:

0.1 Ω

Discussion. If you look at the RETMA Color Code for power transformers, you will be able to check your answers to the color questions in Step 1 of this experiment. As you were told before, the primary leads are black. The high-voltage secondary leads are red, the low-voltage leads of the secondary are green, and the lead to the center tap of the high-voltage secondary is red-yellow. This color code gives you a very easy and convenient way to identify the different windings, just as it does in the case of resistors and capacitors.

There are many times when it is not possible to use the color code because the leads may be too dirty or otherwise discolored. In this case, you may not be able to see the colors clearly. Sometimes, a power transformer has lugs for terminals rather than leads. Whatever the reason may be, if you are not able to use the color code, it is possible to identify transformer windings by checking resistances. The results that you obtained from Step 2 of this experiment should be approximately as follows: primary winding (black leads), 13 ohms; high-voltage secondary (red leads), 490 ohms; high-voltage secondary, between center tap and one of the ends (red lead and red-yellow lead), 245 ohms; low-voltage secondary (green leads), 0.15 ohms. The values you obtained may be slightly different from the ones given here, but they should be about the same.

What is the reason behind measuring resistances in order to identify transformer windings? You know from your study of resistance that a coil of wire with 100 turns has more resistance than a coil of the same diameter wound from the same type of wire that has only 50 turns. The reason is that a 100-turn coil is longer, and adding length to a wire increases its resistance. In the transformer you used in this experiment, the high-voltage secondary is a step-up winding. In Theory Lesson 12, the section on transformers taught you that a step-up ratio calls for more turns in the secondary winding than in the primary. Therefore, since the high-voltage winding has more turns than the primary, its resistance should be higher than

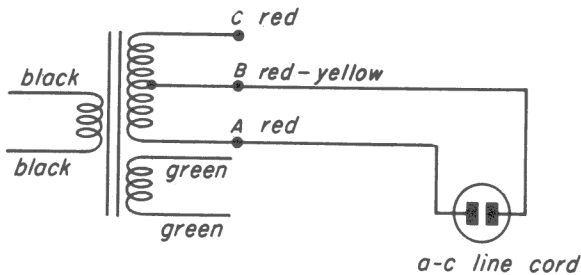


Fig. 13-8

the primary's resistance. Also, the low-voltage winding of the secondary has fewer turns than the primary, and, therefore, the resistance of the low-voltage winding is lower than that of the primary. As a matter of fact, the winding with the lowest resistance is the low-voltage winding of the secondary, and you can identify it by resistance measurement if the colors are not clear enough to be seen. The winding with the next higher resistance is the primary; and the one with the highest resistance is the high-voltage secondary winding. The resistance between center tap and one end of the high-voltage secondary is about one-half the resistance of the high-voltage winding. To determine which are the primary leads and which are the secondary leads, decide what the resistances should be in comparison to the ratios, and then take resistance measurements.

EXPERIMENT 13-6.

To measure the output voltages of the various windings of the power transformer.

Procedure.

Step 1. Temporarily connect one side of the a-c line cord to one of the primary (black) leads. Tape the connection.

Step 2. Temporarily connect the other side of the a-c line cord to the other primary lead, and tape the connection.

Step 3. Carefully arrange all the other transformer leads so that each one is free and not in contact with any other leads.

Step 4. When you are sure that all the leads are not in contact with any other, and will stay that way, insert the male plug of the line cord into an a-c power outlet.

Caution: Remember that the power transformer must be connected only to a 100-130 volt, 60-cycle a-c power source. The transformer may be damaged if connected to a power source of different frequency or voltage.

Step 5. Check to see that the meter leads are inserted in the red and black jacks on the meter. Set up the meter to the 300 VAC range, and the FUNCTION switch to AC.

Step 6. Hold the meter leads by the test prods, keeping your hands and fingers away from the exposed tips.

Step 7. Measure the voltage between one of the red leads and the red-yellow lead, and record it here:

234V

Step 8. Measure the voltage between the other red lead and the red-yellow lead, and record it here:

234v

Step 9. Turn the RANGE switch to the 15 VAC position, and measure the voltage across the low-voltage (green) leads, and record it here:

6v

Step 10. Disconnect the male plug from the a-c outlet, and remove the line cord from the transformer.

Discussion. The output voltages that you should measure are typical of those that you will find in small radio receiver transformers of this type. About 225 volts should be measured across each half of the high-voltage winding, and about 7 volts across the low voltage windings. Your voltage need not be exactly the same as the figures given. First

225 ^{.04} 19.000

$$\% = \frac{225 - 234}{225} = \frac{-9}{225} = .04 = 4\%$$

Experiment 13-7

13

of all, our figures are based on a line voltage of 120 volts, and your line voltage may be more or less than this. Second, no two transformers are exactly alike, due to manufacturing tolerances. If your voltages are more or less than those given, calculate the *percentage of difference* between them. This is done by the formula:

$$\% \text{ Difference} = \frac{\text{Given } E - \text{Measured } E}{\text{Given } E} \times 100$$

As long as your voltages do not differ from the given voltages by more than 20%, all is well.

EXPERIMENT 13-7

To connect the high-voltage secondary of the power transformer as an autotransformer.

Note: Remember that the power transformer must be connected only to a 100- to 130-volt 60-cycle a-c power line.

Procedure.

Step 1. Connect one lead of the a-c line cord to one of the red leads of the high-voltage secondary of the power transformer. Connect the other line-cord lead to the center tap (red-yellow) lead of the transformer as shown in Fig. 13-8. Be careful that no two leads short together.

Step 2. Tape the black and green leads separately so that they cannot make contact with each other.

Step 3. Turn the FUNCTION switch of the multimeter to AC and the RANGE switch to 300 VAC.

Step 4. Plug the a-c line cord into a convenient outlet. Measure the voltage between points A and B and record it here:

110V

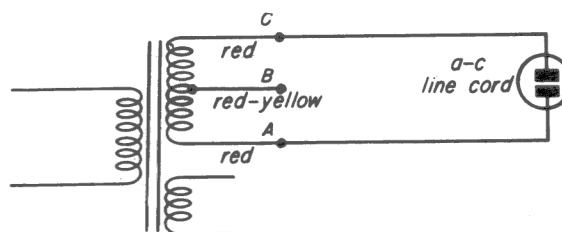


Fig. 13-9

Measure the voltage between points A and C and record it here:

230V

Step 5. Disconnect the a-c line cord from the outlet.

Step 6. Disconnect the a-c line cord lead from the high-voltage center tap (red-yellow) lead and connect it, instead, to the free high-voltage (red) lead, as in Fig. 13-9. Be careful not to short the connections.

Step 7. Plug the a-c line cord into the electric outlet. Measure the voltage between the red-yellow lead and one of the red leads of the high-voltage secondary, and record it here:

55V

Measure the voltage between the red-yellow lead and the other red high-voltage secondary lead, and record it here:

55V

Measure the voltage across both red leads and record it here:

110V

Step 8. Remove the line cord from the electric outlet.

Discussion. The hookup used in this experiment is the same as the one you find in an autotransformer. You remember that, in an autotransformer, the same winding is used for both the primary and the secondary. The power is connected between one end of the coil and a tap somewhere along the coil. The part of the coil to which power is applied is the primary, and the rest of the coil is the secondary. The rules about turns ratio that apply to autotransformers are the same rules that apply to transformers in general. If the tap on the coil is halfway between the two ends of the coil, each side of the coil has the same number of turns, and the voltage should be the same on both sides of the tap. In Step 4, you measured the voltage of the secondary (the whole winding) when

120 volts a.c. was applied to the primary (half of the winding). Since the whole winding has twice the number of turns that one-half the winding has, the voltage you measured should have been about twice the line voltage. No transformer is perfect, so there may have been slightly more or less than exactly twice the line voltage. This was a step-up autotransformer.

In Step 7, you measure a voltage across each half of the high-voltage winding when the entire winding was used as the primary and connected to the a-c outlet. You should have found the reading for each half equal to about one-half the line voltage. This, then, was a step-down transformer.
